

Chapter 1 Introduction

1-1. Purpose

The purpose of this manual is to provide an overview of coastal geology and a discussion of data sources and study methods applicable to coastal geological field studies. "Coastal geology" is defined as the science of landforms, structures, rocks, and sediments with particular emphasis on the coastal zone. Material in this manual has been adapted from textbooks and technical literature from the fields of geology, geomorphology, geophysics, oceanography, meteorology, and geotechnical engineering. The practicing scientist involved in coastal projects is expected to be able to obtain a general overview of most aspects of coastal geology and to be able to refer to the reference list for additional information on specific topics.

1-2. Applicability

This manual applies to all HQUSACE elements, major subordinate commands, districts, laboratories, and field operating activities having civil works responsibilities. The intended audience is engineers, geologists, and oceanographers who have had limited experience in the coastal zone and need to become more familiar with the many unique and challenging problems posed by the dynamic and intricate interplay among land, sea, and air that occur at the coast. "Coastal zone" is loosely defined as the region between the edge of the continental shelf and the landward limit of storm wave activity (to be discussed in more detail in Chapter 2). The definition is applicable to the edge of oceans, lakes, reservoirs, and estuaries - effectively any shore that is influenced by waves. For those with extensive coastal practice, we hope that this manual will provide review material and suitable references to enable them to address more challenging projects.

1-3. References

References cited in the text are listed in Appendix A. Because of the broad nature of this manual and the fact that different users have different needs, all of the references have been listed together in Appendix A, rather than dividing them into the categories of "required" and "related" publications. Certain high quality books specializing in coastal geology, such as Carter's (1988) *Coastal Environments*, Davis' (1985) *Coastal Sedimentary Environments*, and Pethick's (1984) *An Introduction to Coastal Geomorphology*, could be considered "required reading" for anyone working at the coast, but it is a gross

imposition to insist that the already busy coastal engineer read multi-hundred page texts before he is allowed to work at the shore. Therefore, it is hoped that the coastal worker will avail himself of the reference list, choosing works and reviewing appropriate sections that are most pertinent to his specific project or study area. Many of the citations are of a review nature and contain long bibliographies. A glossary of geologic terms is provided in Appendix B.

1-4. Background

a. Since man has ventured to the sea, he has been fascinated by the endless variety of geomorphic landforms and biological habitats that present themselves at the coast. With the exception of high altitude alpine, a full spectrum of environments is found around the world's coastlines. These range from icy arctic shores to rocky faulted coasts to temperate sandy barriers to tropical mangrove thickets, with a myriad of intermediate and mixed forms. Man has gone to the sea for food, for commerce, for war, and for beauty. He has built his homes and cities at the coast. He has also been hurt by the sea, terrorized by its occasional violence, and baffled by the changes that the sea has wrought on the land in remarkably short time spans. In hours, beaches disappear; in days, new inlets are cut; in a generation, cliffs crumble. His coastal works have often been buried in sand, swept away, or pounded into rubble, frustrating his most worthy engineering efforts. Why? What controls these mighty forces of change?

b. The answers have been elusive. Nevertheless, over the centuries, man has attempted to manage the power of the sea. With a disregard for the realities of nature and a surfeit of *hubris*¹, he has built ever more massive structures to protect cities placed in ever more precarious locations. Unfortunately, many of these coastal works have been constructed with little attention to the overall physical setting in which they were placed, with little respect for the delicate balances of sediment supply, water quality, and biological habitat that are intimate elements of the coastal environment.

c. In the latter part of the 20th century, it has become clear that three primary factors shape the coast: the regional *geology* which provides the setting, the

¹*Hubris*, a Greek term which cannot be fully translated, represents an attitude of overweening pride or arrogance - the end result of a search for self-assertion that challenges everything and defies everyone.

physical and *dynamic processes* which affect it, and the *ecology* and *biology* of the plants and animals that inhabit it. This manual concentrates on the first of these topics, geology. This broad subject encompasses both the geomorphology (the shape and form) of the landforms and the nature of the ancient strata that underlie or outcrop in the region. The forces that shape, and are shaped by, the coast are part of the overall picture, although here geology merges with the other earth sciences of meteorology and oceanography.

d. This volume has ambitious goals:

- To review overall geological, environmental, and climatological settings of the world's coasts.
- To describe particular shore types in detail.
- To explain how shore types are created by and interact with the forces of waves, currents, and weather (sometimes known as "morphodynamics").
- To describe field methods and data analysis procedures applicable to field studies at the coast.

e. The emphasis in this volume is on features and landforms that range in size from centimeters to kilometers and are formed or modified over time scales of minutes to millennia (Figure 1-1). Micro-scale geological interactions, such as the movement of individual grains in fluid flow or the electrochemical attraction between clay platelets in cohesive sediments, are left to specialty texts. Because of space and time limitations, it has been impossible to present more than a brief introduction to meteorology and oceanography.

f. Another subject of crucial importance to coastal researchers is biology. The biological environment is partly established by the geological setting. Conversely, biology affects coastal geology in many ways:

- Coral reefs and mangroves have created large stretches of coastline.
- Cliff erosion is accelerated by the chemical solution and mechanical abrasion caused by some organisms.
- Dunes and barriers are stabilized by plants.

- Lagoons and estuaries slowly fill with the by-products of plants and the sediment they trap, forming wetlands.

These topics are reviewed in this text, but details of the flora and fauna that inhabit the coast unfortunately cannot be covered here.

g. Geotechnical aspects of coastal geology, such as the choice and use of rock as a building material or calculation of underwater slope stability, are not covered in this manual. Eckert and Callender (1987) summarize many aspects of geotechnical engineering in the coastal zone. Use of rock in coastal and shoreline engineering is covered in Construction Industry Research and Information Association (1991) and EM 1110-2-2302.

h. This manual will have served its purpose if it convinces the reader that no coastal feature or setting exists in isolation, but rather that every part is influenced by the other, that the coast is a living entity that changes, grows, and evolves. An understanding of, and a respect for, the underlying geological setting of any particular coastal site is an absolute requirement for safe, economic, and successful coastal project planning, design, construction, maintenance, and administration.

1-5. Organization of This Manual

This manual covers three broad types of information:

- Basic background concepts related to coastal geology.
- Descriptions of specific coastal forms and environments.
- Guidance on conducting coastal geological investigations.

a. Chapter 2 provides general background information on coastal nomenclature and concepts like datums and water levels. It also discusses waves and tides and changes in sea level - processes which cause geologic change in the coastal zone. The intent is to give a reader a basic understanding of some of the processes which cause coastal change and serve as a foundation for the discussions of specific coastal features in the following chapters.

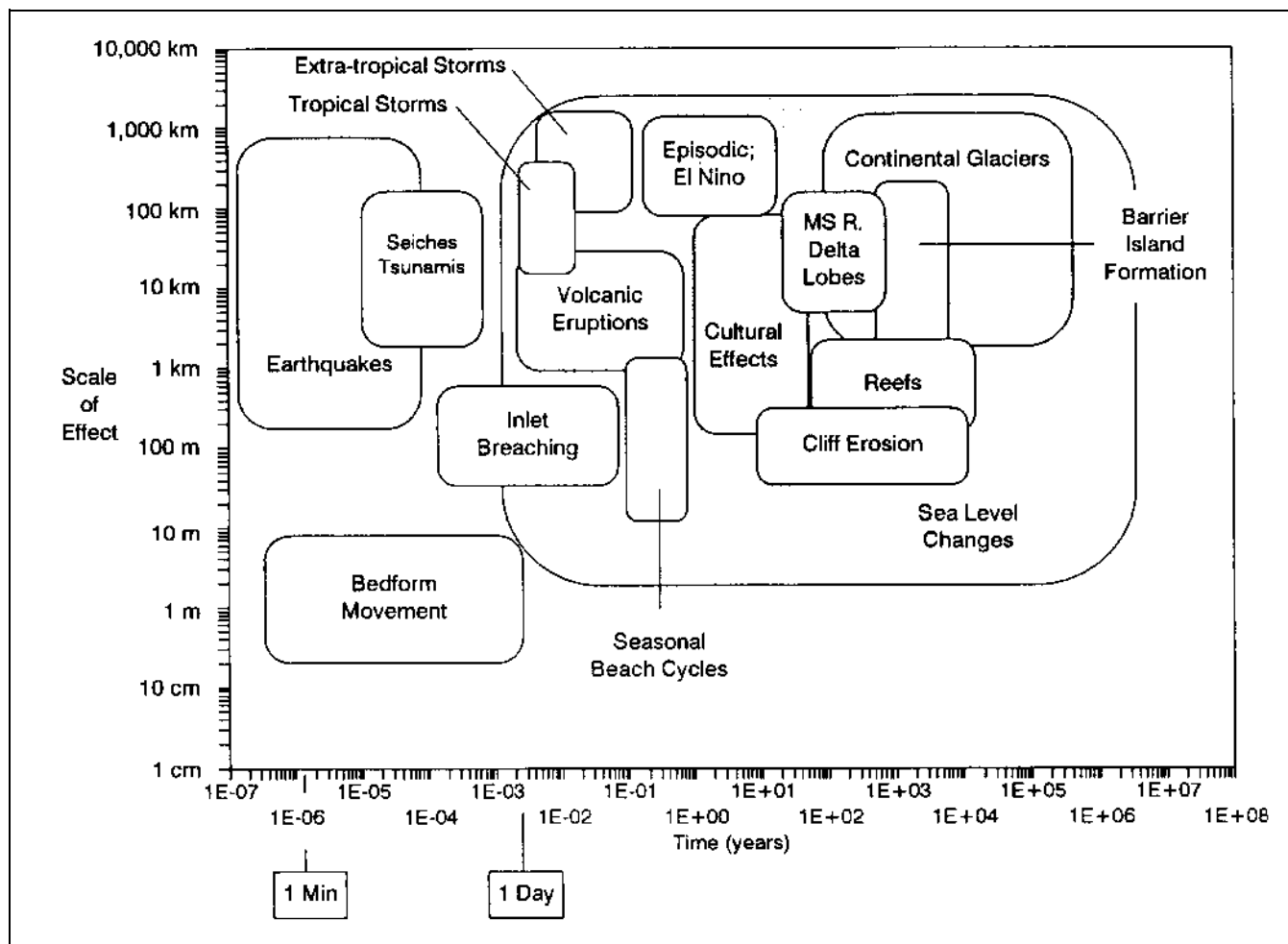


Figure 1-1. Temporal and spatial scales of phenomena addressed in this manual

b. Chapter 3 introduces the coastal classification scheme of Francis Shepard (1937; 1948; 1963; 1973) and continues with discussions and examples of specific coastlines following Shepard's outline.

c. Chapter 4 discusses morphodynamics of deltas, inlets, sandy shorefaces, and cohesive shorefaces.

d. Chapter 5 is a description of technologies for examining and assessing the geologic and geomorphic history of coasts. The chapter is not a step-by-step "how-to" manual for conducting coastal studies but rather is a description of what type of data to acquire, what types of instruments to use, how to anticipate data errors, and how to analyze data, either acquired directly from field studies or obtained from secondary sources. An

underlying assumption in this chapter is that the coastal researcher will, in many cases, have a large amount of data already available and will need to organize, examine, and use this material to the best possible advantage before conducting additional field studies. For this reason, emphasis is placed on data display and organization and error checking.

1-6. Proponent

The U.S. Army Corps of Engineers proponent for this manual is the Geotechnical and Materials Branch, Engineering Division, Directorate of Civil Works (CECW-EG). Any comments or questions regarding the content of this manual should be directed to the proponent at the following address:

EM 1110-2-1810
31 Jan 95

Headquarters, U.S. Army Corps of Engineers
Attn: CECW-EG
20 Massachusetts Ave., NW
Washington, DC 20314-1000

1-7. Acknowledgement

Authors and reviewers of this manual are listed in Appendix C.